Using the Building Control System in Commissioning

- Needs and Examples from JAPAN

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ASHRAE winter meeting at Anaheim, CA Jan 28, 2004

Why Cx in Japan?

- Building owners pay much more attention to Energy Efficiency than before.
- And they try to suffice ISO-9000 and 14000 Series requirement to obtain Social Reputation.
- As energy conservation is the key issue, much more importance is paid on Operation Stage rather than Design Stage.
- As a result the trend is for Specification Design to give the way to Performance Design

Why Cx in Japan? Cont.

- Quality Control in construction industry has been successful up to 10 years ago.
- However due to Japanese bad recession in these days and open market policy the industry cannot maintain any more the Life-span Supporting Service based on Japanese business tradition.
- Now the level of performance varies from building to building, and some owners are happy and some are unhappy.

SHASE Cx Process Guideline

Draft will be completed before March 2004

- **TI**

  Testing and Inspection of Components when installing

TAS

Testing, Adjusting and Start-up of Total System

Mainly done by Construction Company

- **Already has been done well based on QC strategy**

- **FPT**

  Functional Performance Testing

Supervised by Cx Authority with the support of construction company

Main Cx

Cx Using Building Control System

- **Building Control System can be used at**

1) **FPT stage**
2) **Post acceptance Cx stage**
   (Generally one year tuning-up period)
3) **Ongoing Cx stage**
4) **Retro- or Re- Cx stage (ESCO)**

What Cx Tool ? -- Questionnaire Survey

A report of Annex 40, Kista Sweden Meeting in Apr., 2002

- Tools to predict ideal states of operation with adequate precision
- Tools that can display actual operation data and target values simultaneously to perform optimum operation
- Tools that can improve the accuracy of the estimated AC load based on actual operation data
- Analyzing and evaluating tools that can perform operation / control tests for all seasons

What Cx Tool ? -- Questionnaire Survey Cont.

- Tools that can show possible causes of faults and deterioration of components by the aid of accumulated operation data
- Simulation tools that only require small amount of building data that helps wide use of the tools.

BCS and Cx tools must be simple enough to be easily understood by maintenance personnel

Examples of Cx Tools

- **Initial Cx / Bottom Up Approach:**

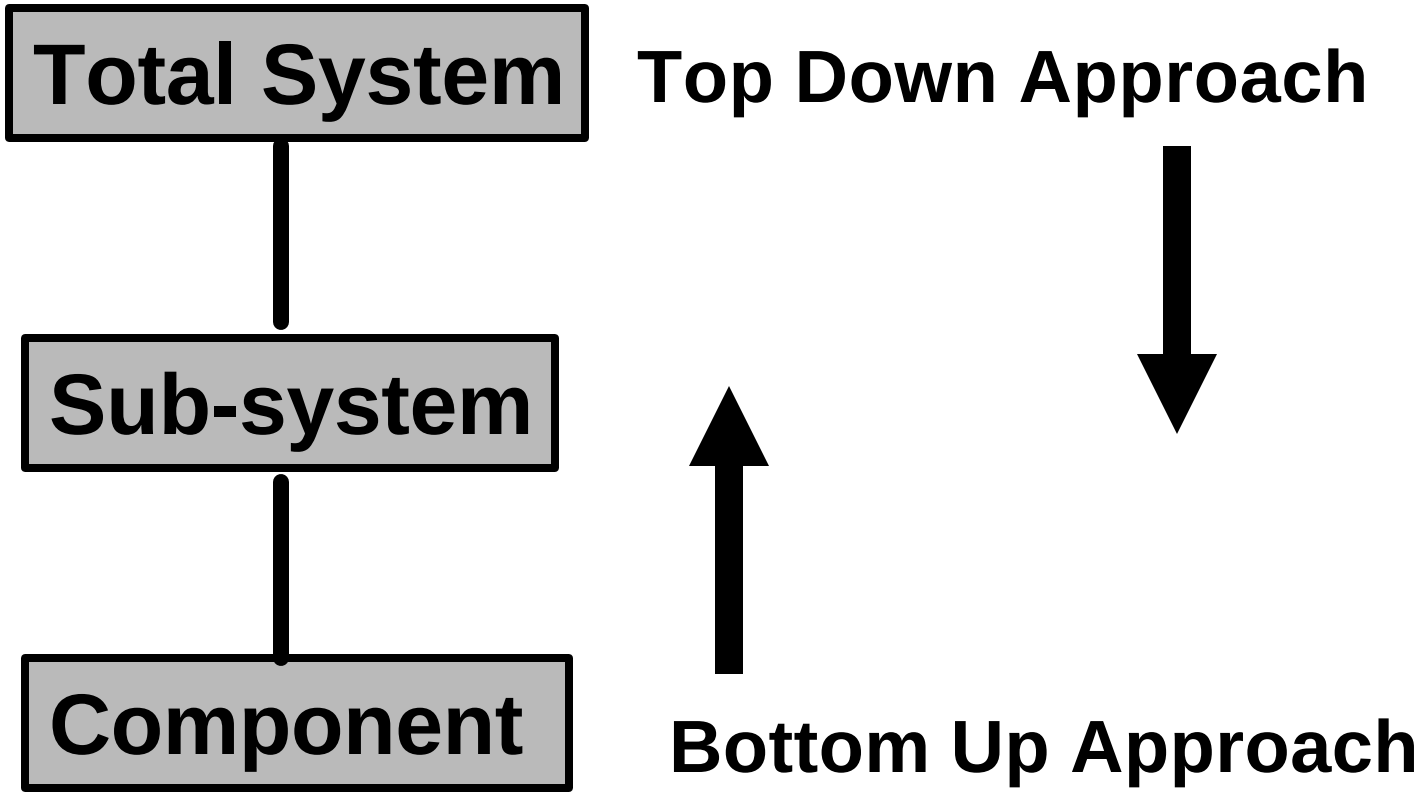
  Control Logic Tracer
- **Ongoing Cx / Bottom Up Approach:**

  Fault Detection of VAV Terminal Units
- **Ongoing Cx / Top Down Approach:**

  Basic Energy and Environment Data Sheet

Works presented at Annex40 meeting

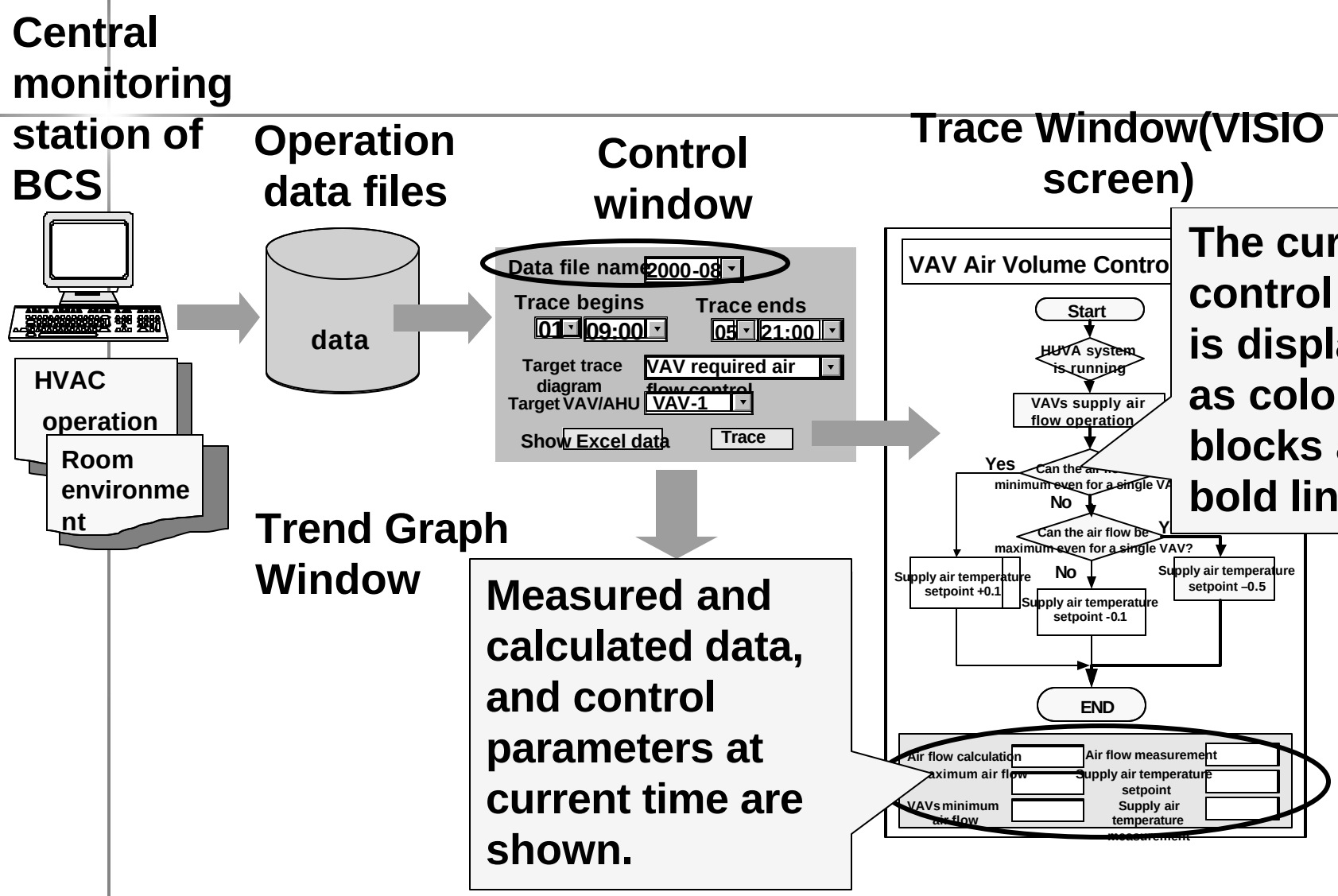
Examples of Cx Tools



(1) Initial Cx / Bottom Up Approach: Control Logic Tracer (CLT)

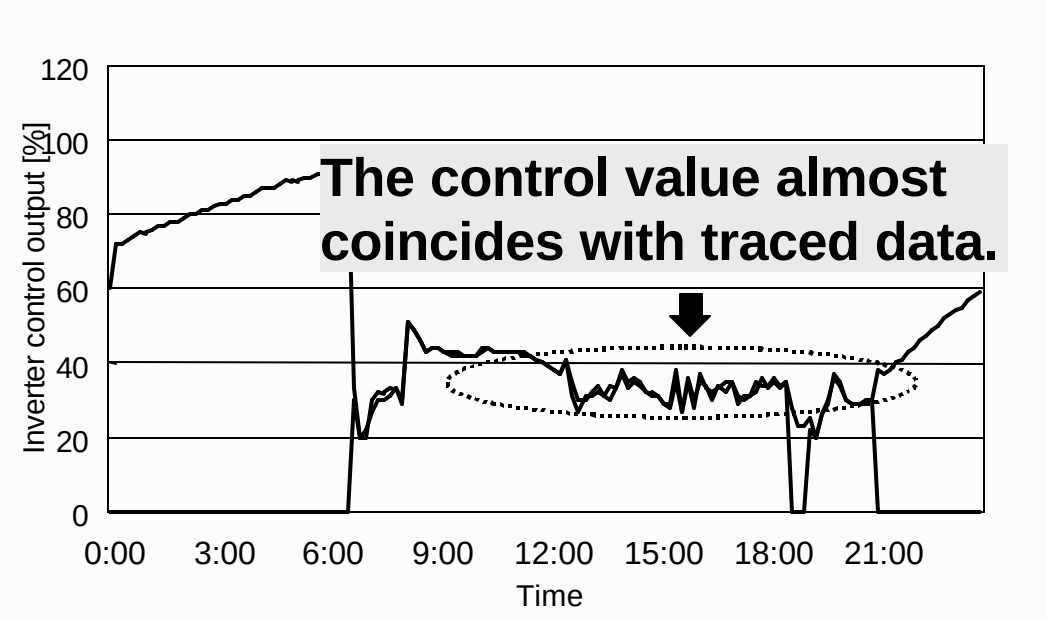
- CLT originally has been developed for water type thermal storage systems.
- Sophisticated control logic often makes faulty operation.
- The CLT shows graphically the control path in the flowchart in real time.
- CLT is an emulator.

Configuration of Control Logic Tracer

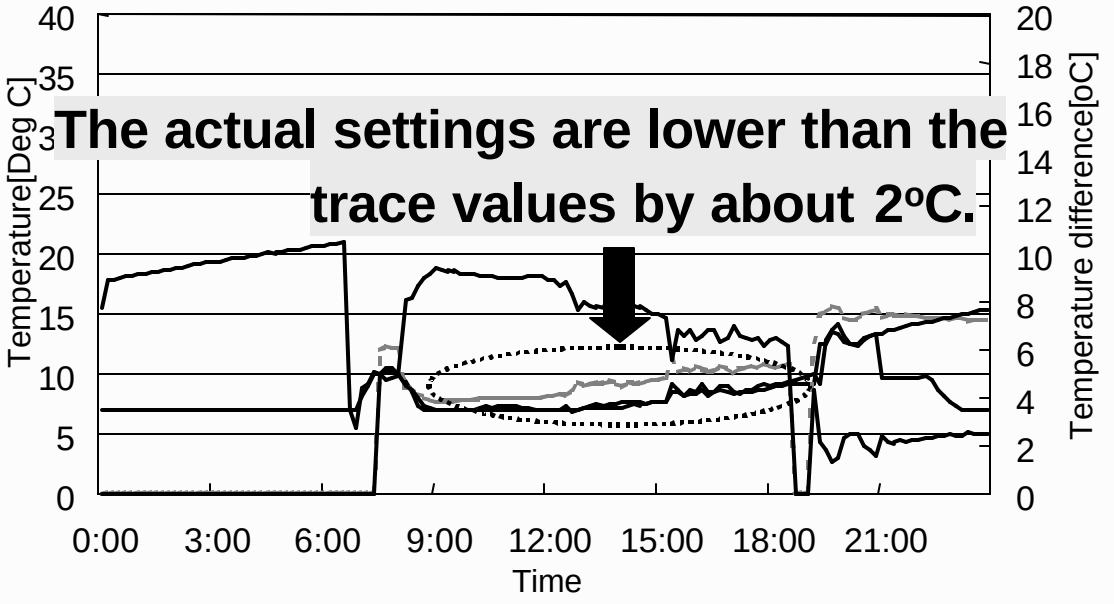


Examples

■ **No fault case: Inverter control signal for a pump**



■ **Faulty case: Supply child water temperature**



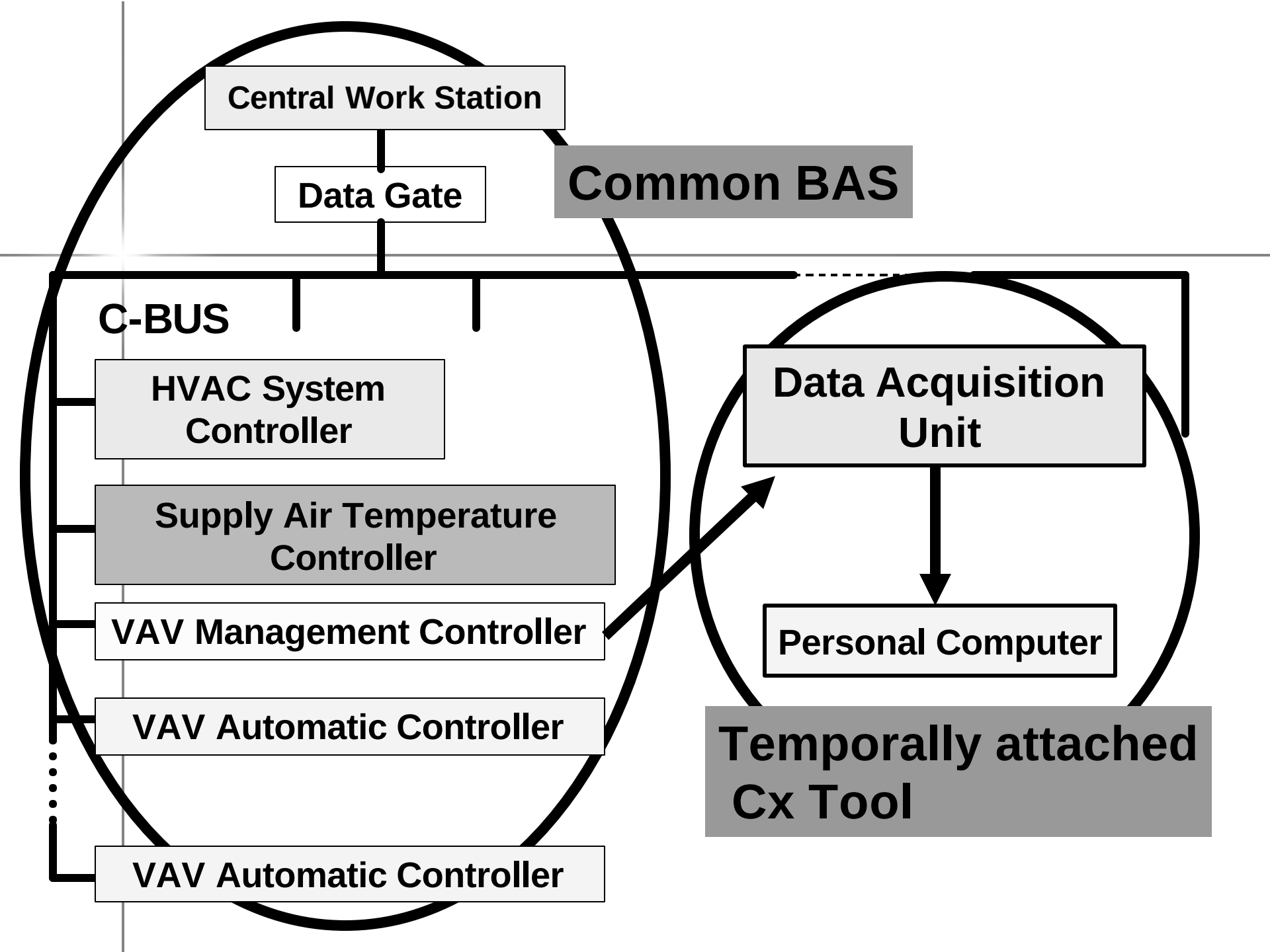
In the case of faulty operation

- **Visual dynamic trace can give clear understanding of how HVAC control logics are working in real time.**
- **Whether faulty operation exists due to control logic problems or not can be analyzed efficiently by understanding the present logical state.**

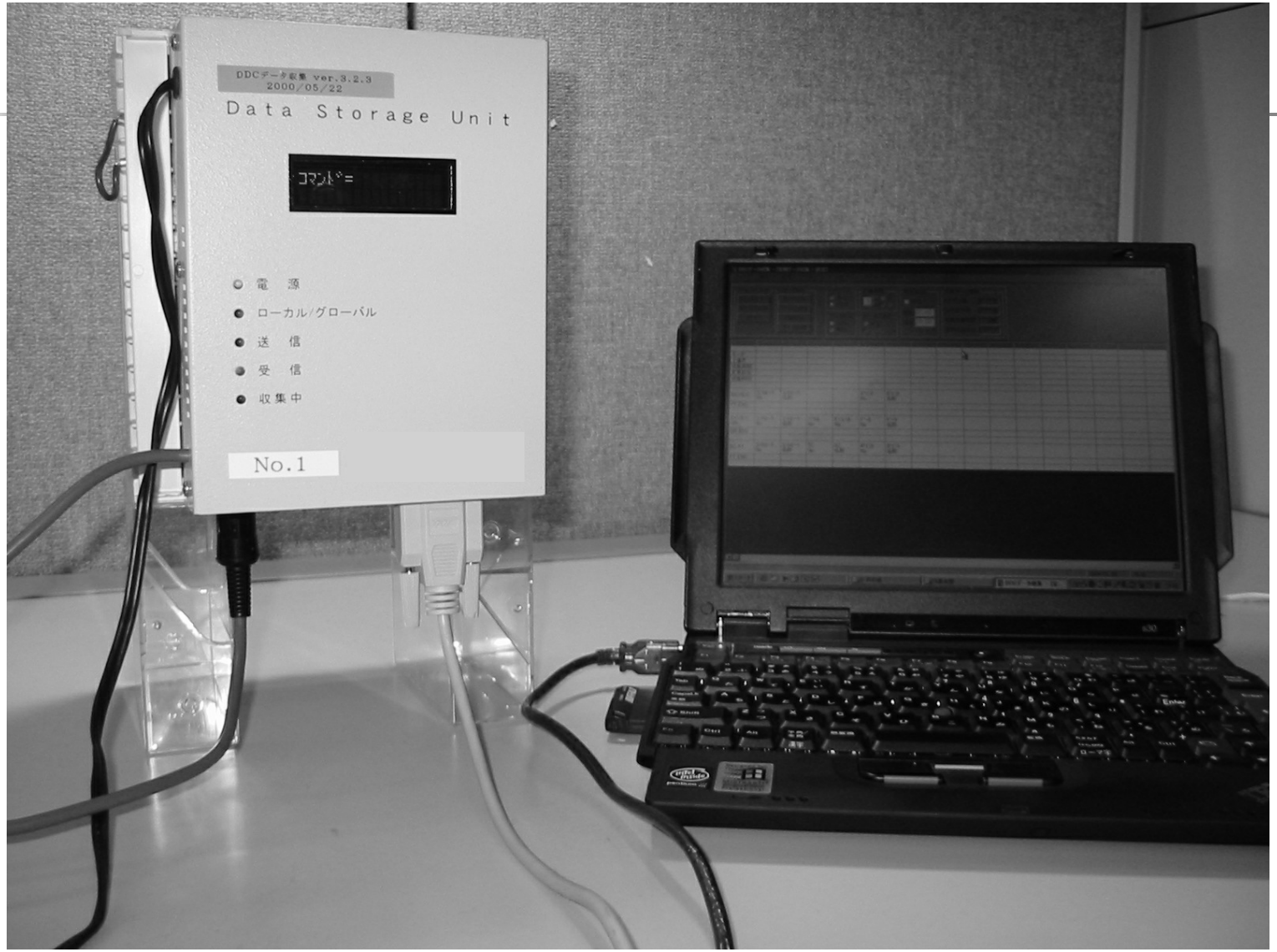
CLT can be a good tool to educate operation and maintenance personnel and also HVAC system designers as well when it is connected to simulation software and emulates the logic state.

(2) Ongoing Cx / Bottom Up Approach: VAV Terminal Unit Fault Detection Tool

- A real building suffers from malfunction problems in VAV terminal units.
- The routine work testing whether the VAV terminal units are working well or not requires tremendous cost because it has about 800 VAV terminal units.
- Development of a computer assisted automatic fault detection tool is needed to reduce the cost and time.
- All the detailed operational data of the VAV terminal units are not collected in the BCS.

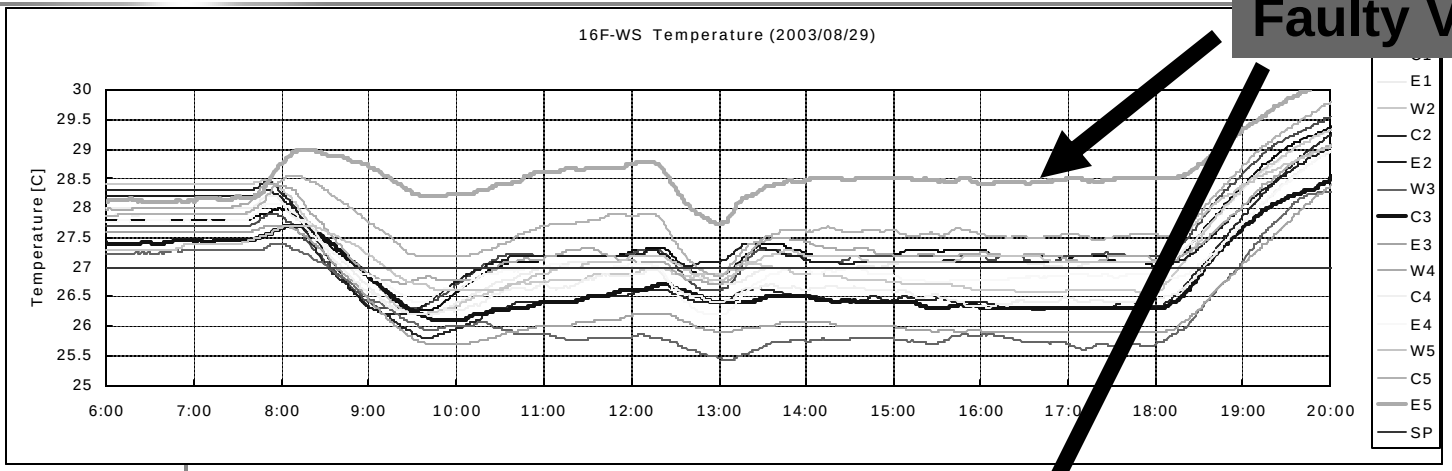

Central Work Station
Data Gate
Common BAS
C-BUS
HVAC System Controller
Supply Air Temperature Controller
VAV Management Controller
VAV Automatic Controller
VAV Automatic Controller
Data Acquisition Unit
Personal Computer
Temporally attached Cx Tool

Data Acquisition Unit



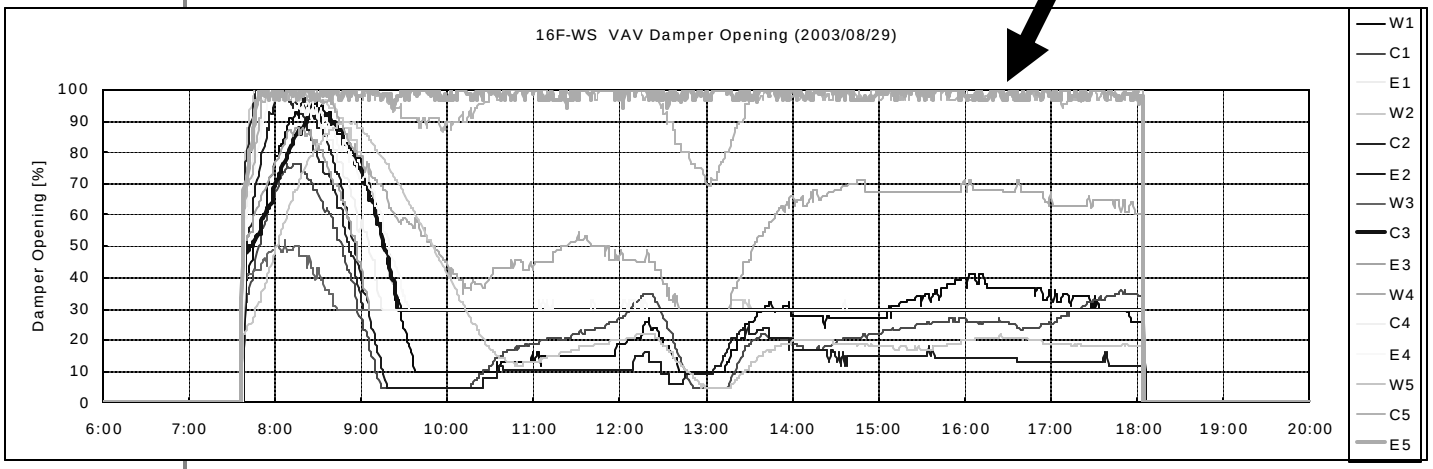
Real Situation and Fault Detection

- Most of all VAV units are not ideally controlled. That is, many VAV units are operated at minimal opening.



Faulty VAV unit

Room Temperature



Signal to VAV damper opening ratio

Real damper opening is not measured.

Fault Detection

- A statistical test method by comparing the performance of each VAV unit is applied.
- According to the test 17 out of 160 units may have malfunction. (6 units had real problems.)
- Even though 13 false alarms occur, this tool can reduce the testing work quite substantially.
- Future remaining issue is the reduction of the alarming failure occurrence rate.

	real falut		total alarm		false alarm		alarming failure	
	number	ratio(%)	number	ratio(%)	number	ratio(%)	number	ratio(%)
close	4	3%	12	8%	9	6%	1	1%
open	2	1%	5	3%	4	3%	1	1%
total	6	4%	17	11%	13	9%	2	1%

(3) Ongoing Cx / Top Down Approach:
Basic Energy and Environment Data Sheet

- **A tool for energy audit and indoor environment evaluation for a whole building level is designed as a analyzing tool.**
- **Only essential data are shown in one page.**
- **The tool intends to standardize the interface of whole building Cx by showing only basic information.**
- **By this feature designers and operators involved in diversified buildings can share the common information and compare the performance of their buildings.**

Marco Cx: Energy Audit and Indoor Environment Evaluation for a Whole Building Level (example)

Energy consumption

Evaluation

Energy and an indoor environ

Energy and IAQ Managem

Sample

A. Building outline

Construction outline

Main use	Office
Total Floor Area	1,697?
Floor	4F

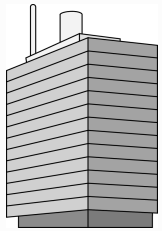
Equipment outline

Heat source Electricity

System Heat pump chiller

Green-ized outline

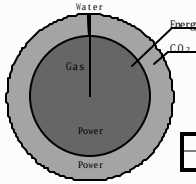
Eaves, a double skin
Double-glazed glass
Natural lighting + light control
Hf lighting
+ Initial illumination compensation
Natural ventilation
Night purge
VWV,VAV



B. Energy consumption

Energy Management

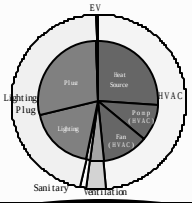
Energy Source



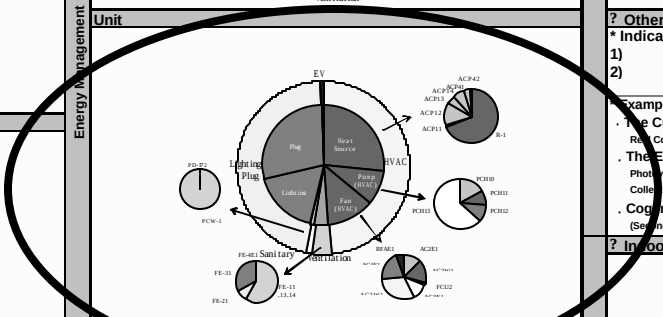
1,951	22.91
MJ/? ?y	[kg-C h ?y]

Type of Use

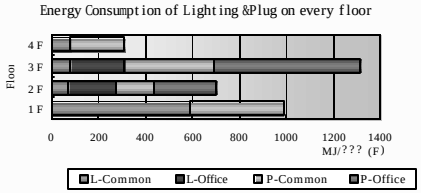
Type of Use(HVAC)



Unit



According to ? floor



C. Evaluation based on a Management Index

Energy Management

? Primary Energy of the Whole Building	Target (Design phase)	Actual Result	
1) Primary Energy Consumption per Area			[MJ/ ?]
Primary Energy Consumption per Total Floor Area			
2) Primary Energy Consumption per Staff			[MJ/ people]
Primary Energy Consumption per Staff			
3) Primary Energy Consumption per Operation time x Floor Area			
Primary Energy Consumption per Floor Area x Operation Time(Blg.)			[MJ/ h(OT<blg.>)]
Primary Energy Consumption per Floor Area x Operation Time(HVAC)			[MJ/ h(OT<HVAC>)]
4) Primary Energy Consumption per Contract Power			
Primary Energy Consumption per Contract Power			[MJ/ kW]

? Energy Efficiency	Target (Design phase)	Actual Result	
1) Heat Source Units			
Heat Source Units (Coolong)			[-](MJ (secondary)/ MJ(primary))
Heat Source Units (Heating)			[-](MJ (secondary)/ MJ(primary))
2) Heat Production			
Heat Production(Cooling)			[-](MJ (secondary)/ MJ(primary))
Heat Production(Hooling)			[-](MJ (secondary)/ MJ(primary))
Heat Production(Total)			[-](MJ (secondary)/ MJ(primary))
3) Heat Conveyance (Chilled&Hot Water<secondary>)			
Chilled-Water Conveyance			[-](MJ (secondary)/ MJ(primary))
Hot Water Conveyance			[-](MJ (secondary)/ MJ(primary))
Cooling-water Conveyance			[-](MJ (secondary)/ MJ(primary))
4) Heat Conveyance (Air)			
Air Conveyance			[-](MJ (secondary)/ MJ(primary))
5) Comprehensive Heat Production			
Comprehensive heat production efficiency			[-](MJ (secondary)/ MJ(primary))

? Other Evaluation	Target (Design phase)	Actual Result	
* Indicate the item taken up for every building.			
1) The Effect of VWV			[-] (kWh/ kWh)
2) The Effect of VAV			[-] (kWh/ kWh)

* Example :

. The Curtailment Effects of Conveyance(VWV, VAV, Control of Ventilation by CO-CO_2 , etc.)

Rated Consumption / Rated Consumption x Operation time

. The Effect of Natural Energy (Photovoltaics, Solar heat)

Photovoltaics Electric Power / Total Electricity Used

Collection quantity of Heat of Solar heat / Plottage

. Cogeneration Synthesis Efficiency

(Secondary side electric power + Quantity of heat) / Injection energy

IAQ Management

? Indoor Temperature & Humidity	Target (Design phase)	Actual Result	
Rate of Indoor Temperature achievement (Coonling)			[-] (h (? *1 - ? *2)/ deg*3)/ h(OT<HVAC>))
? (Heating)			[-] (h (? *1 - ? *2)/ deg*3)/ h(OT<HVAC>))
? (Year)			[-] (average)
Rate of Indoor Humidity achievement (Cooling)			[-] (h (% *1 - %*2) deg*3)/ h(OT<HVAC>))
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Floating Coarse Particulate Concentration			[-] (mg/m*3 (actual result)/ mg/m*3(standard))
CO Concentration			[-] (ppm(actual result) ppm(standard))
CO_2 Concentration			[-] (ppm(actual result) ppm(standard))
Formaldehyde Concentration			[-](mug/m*3(actual result) mug/m*3(standard))

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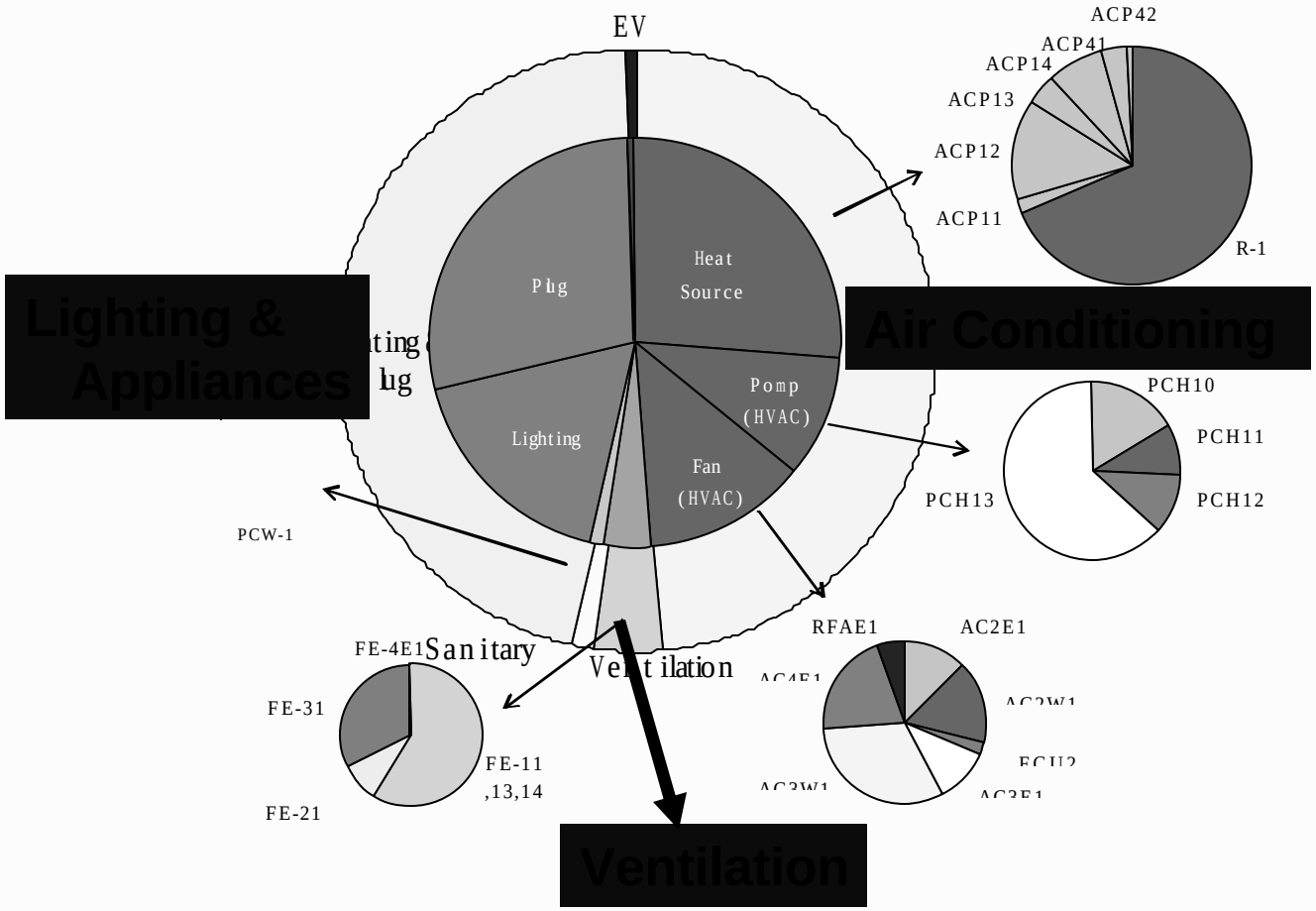
? *2,%*2 :Temperature or Humidity of Setting result value

deg*3: Permission degree

Energy consumption

Sub-system Level



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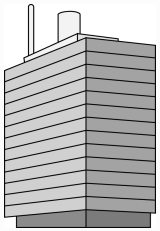
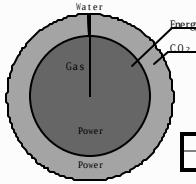


B. Energy consumption

Energy Source



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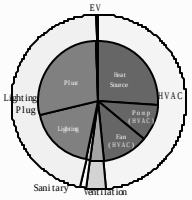

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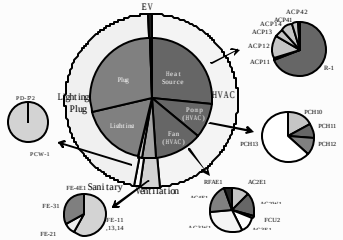

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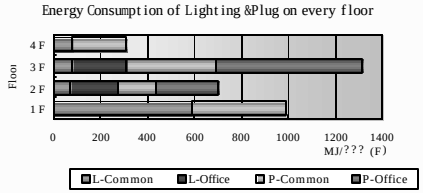

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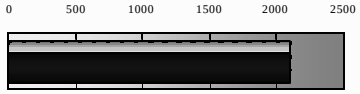
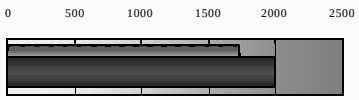
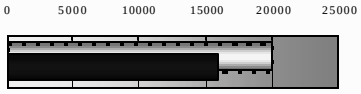
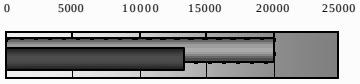
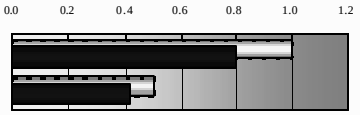
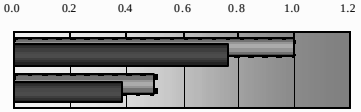
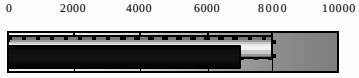
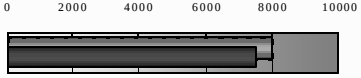
Evaluation by energy consumption

Target (Design)

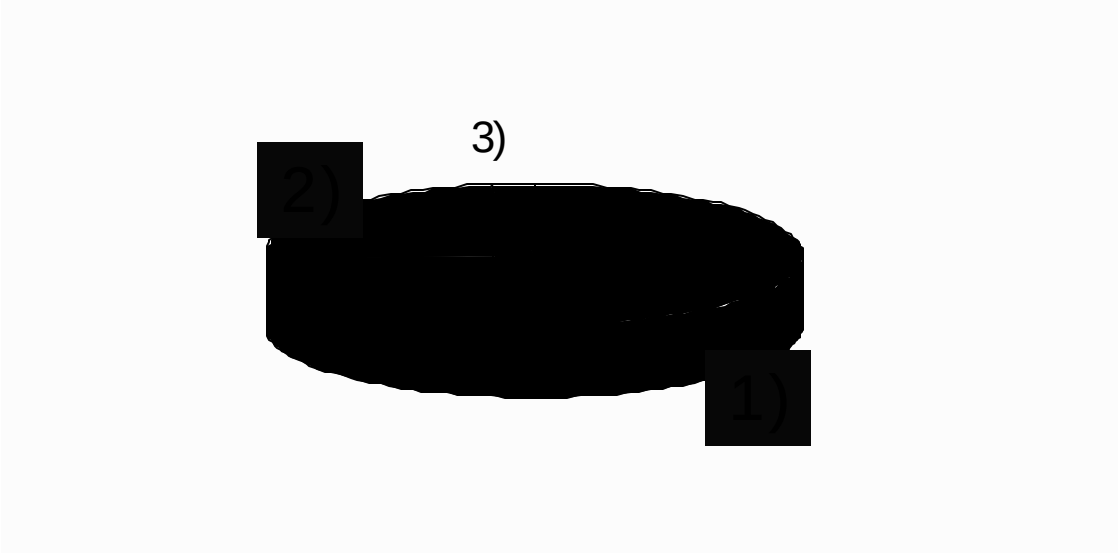
Actual

? Primary Energy of the Whole Building	Target (Design phase)	Actual Result
1) Primary Energy Consumption per Unit Area Primary Energy Consumption per Total Floor Area		
2) Primary Energy Consumption per Person		
3) Primary Energy Consumption per Operation time x Floor Area per Bulding per HVAC System		
4) Primary Energy Consumption per Contract		

Faulty operation may be detected by comparing target (design) values with actual values

Questionnaire survey to building operation personnel about the needs of this sort of tool

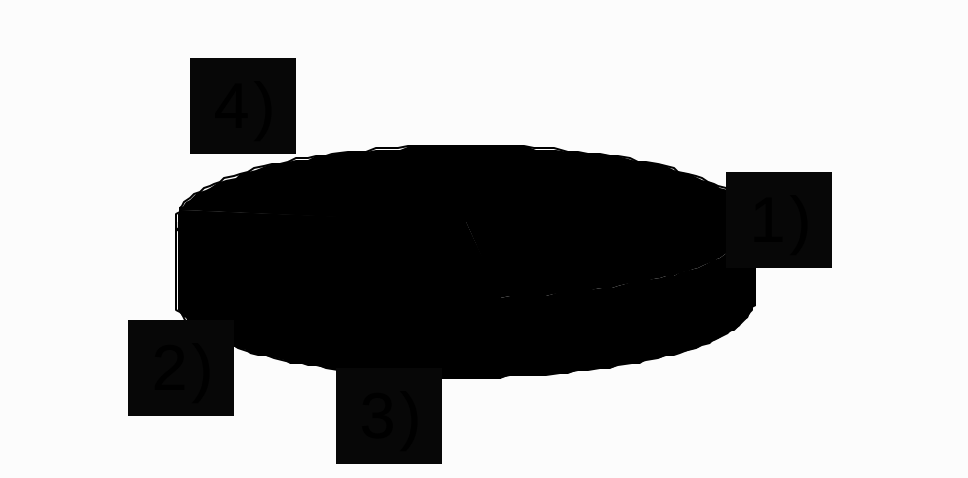
- **Is whole building Cx required ?**



1) Whole building Cx is necessary. (74%)

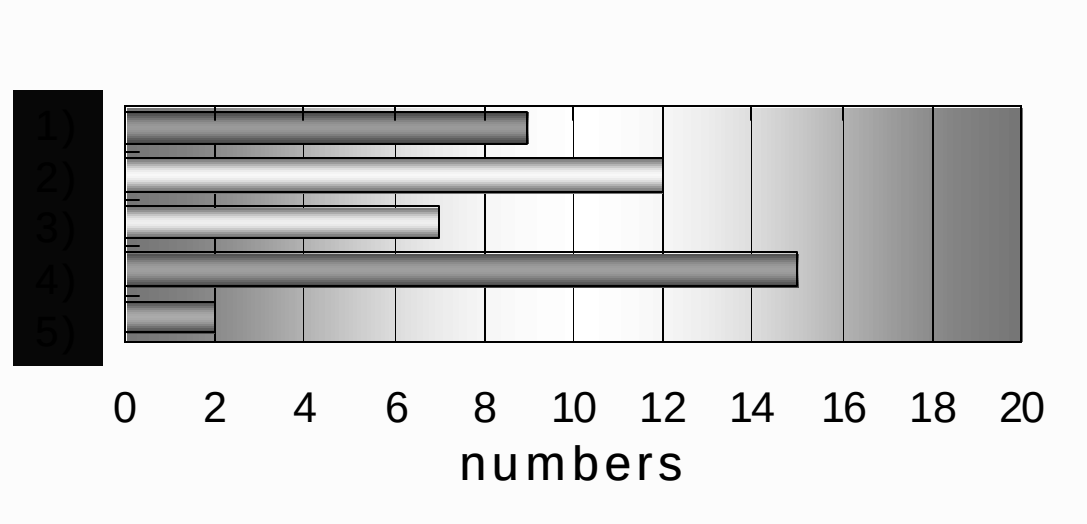
2) Subdivided level Cx is more important. (24%)

Can the automation be realized under the present engineering level ?



1) Already realized. (43%)
2) Future issues but can be solved in near future. (25%)
3) Technologically possible but not installed yet. (15%)
4) Technologically future issues and also difficult to install due to cost problem. (18%)

How the data should be evaluated ?



4) Comparing to past accumulated data. (35%)

2) Comparing to the design data. (31%)

1) Comparing to computationally simulated data. (14%)

3) Comparing to average statistics values. (17%)

E N D

Thank you